

Copernicus Atmosphere Monitoring Service products for wildfire emissions and air quality



Atmosphere Monitoring

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EO Products for Wildfires Monitoring and Forecast

Lisbon, 18-20 October 2022

Acknowledgements:

Sebastien Garrigues, Vincent-Henri Peuch, Melanie Ades, Anna Agusti-Panareda, Richard Engelen, Johannes Flemming, Antje Innes, Zak Kipling, Nicolas Bousserez, Ernest Koffe, Panagiotis Kountouris, Francesca Di Giuseppe (ECMWF)

CAMS development teams



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THE EUROPEAN UNION



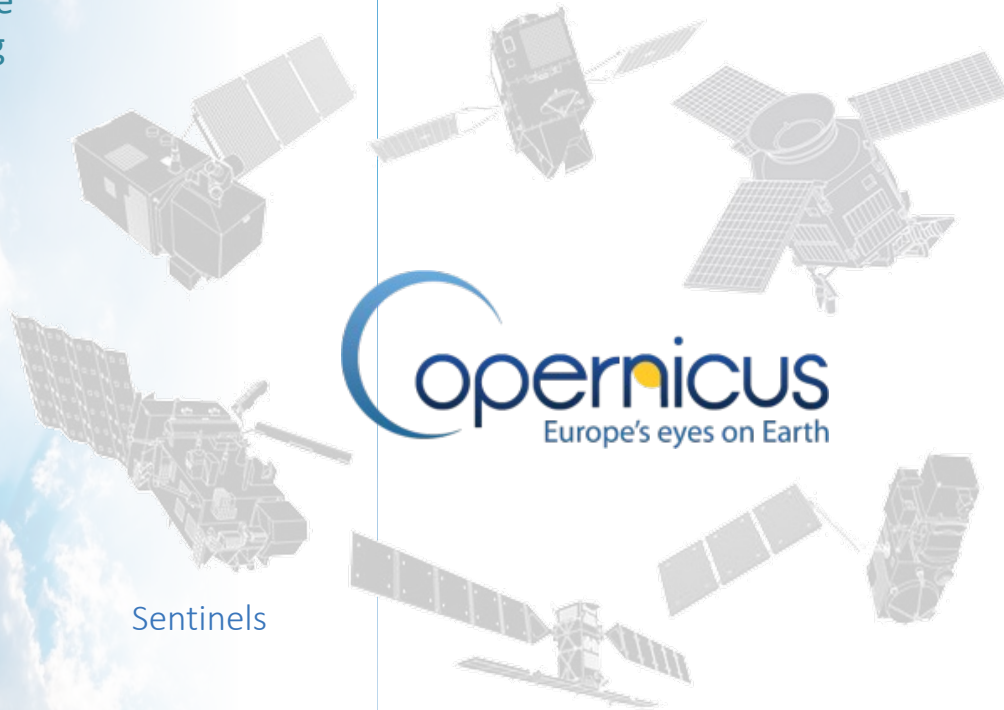
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Atmosphere
Monitoring

COPERNICUS AND ECMWF



Sentinels

Observations
feeding into
value-added
Services



Atmosphere



Climate



Land



Marine



Emergency



Security

Copernicus is the European Union's operational Earth Observation and Monitoring programme, looking at our planet and its environment for the ultimate benefit of all citizens.

User-driven with free and unrestricted data access



Service is implemented by ECMWF



ECWMF is contributing to the Service



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Monitoring

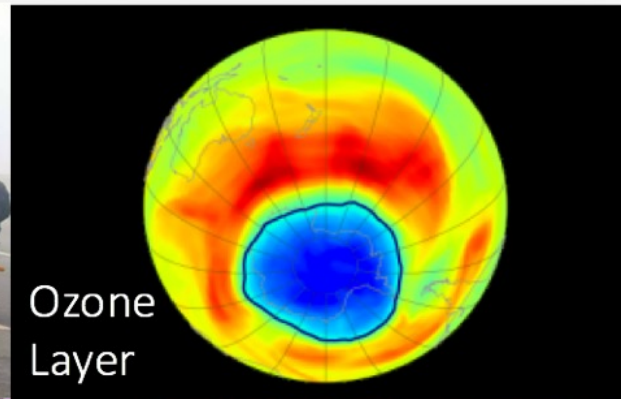
Monitoring atmospheric composition across scales



Disasters



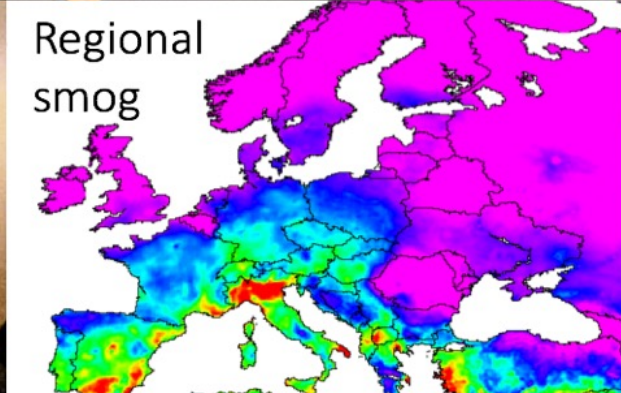
Visibility, radiation



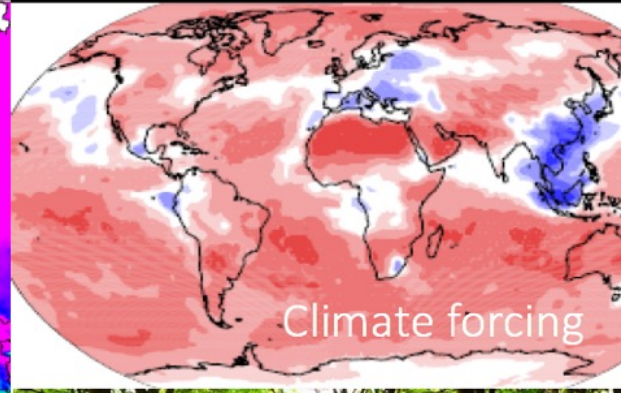
Ozone
Layer



Urban smog



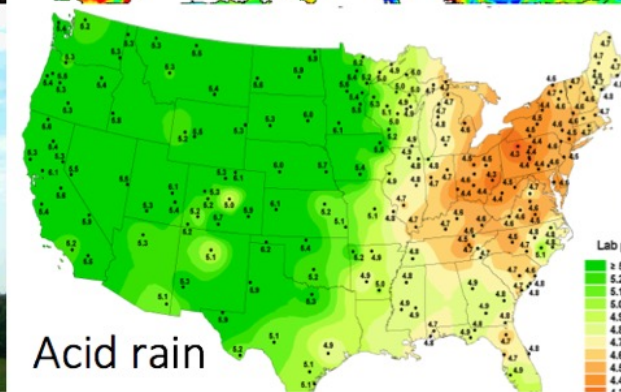
Regional
smog



Climate forcing



Plume dispersion



Acid rain



Biogeochemical cycles

Local < 100km

Regional 100-1000km

Global > 1000km

from D. Jacob (Harvard)

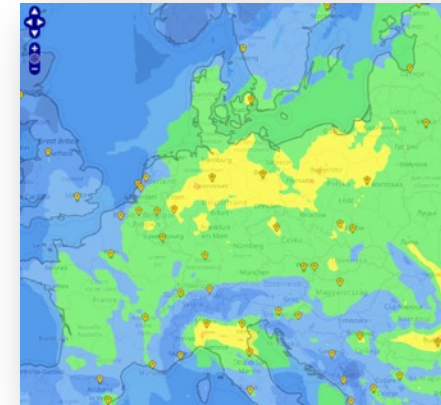


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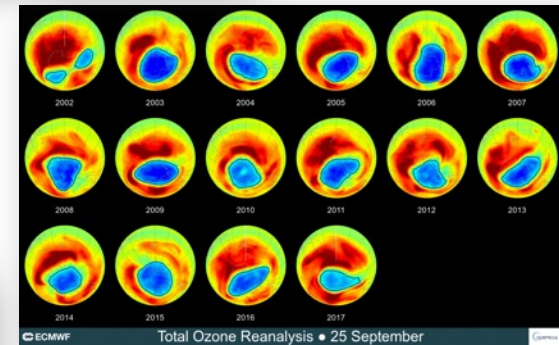
CAMS: COPERNICUS ATMOSPHERE MONITORING SERVICE



<http://atmosphere.copernicus.eu>

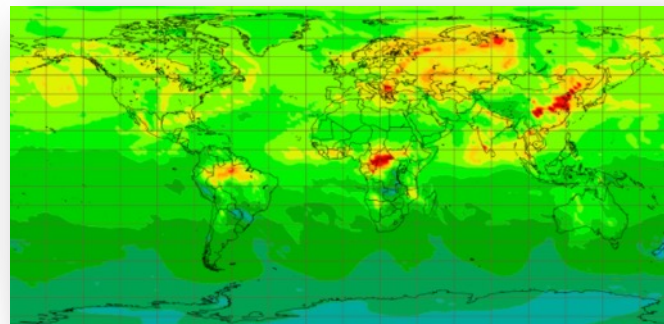
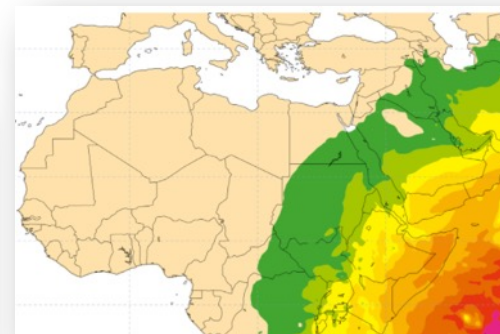


*European
Air Quality*



Ozone layer

*Solar radiation and
UV index*



Global analyses, forecasts and reanalyses

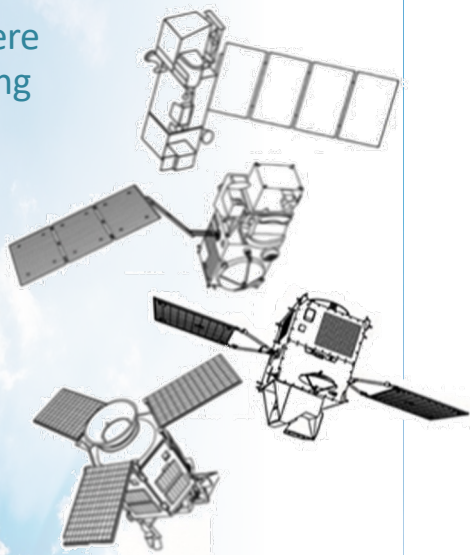


*Emissions and
surface fluxes*

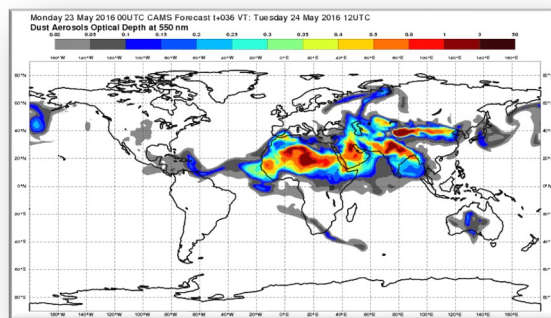
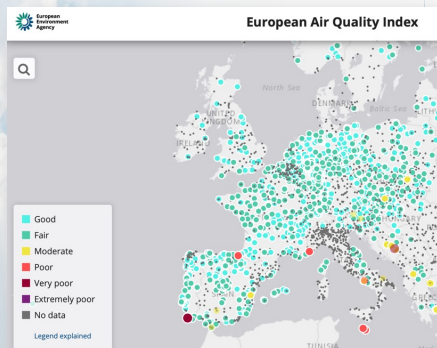


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CAMS INFORMATION FLOW I

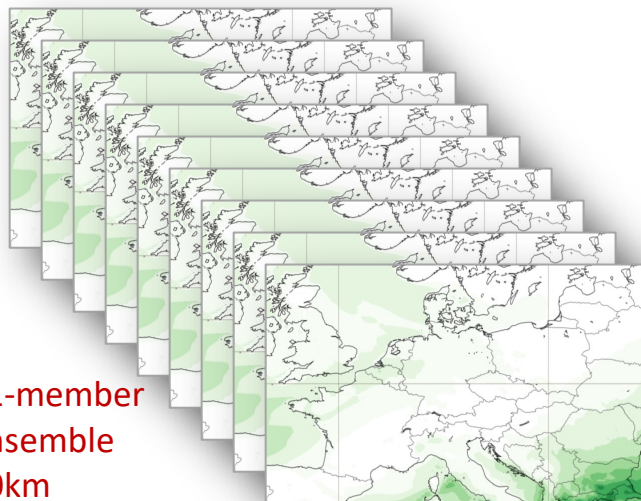


Earth Observation
from satellite (>75
instruments) and in-
situ (regulatory and
research)



IFS 40km (oper) / 80km (rean) Globe

CAMS main operational data
assimilation and modelling systems

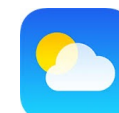


11-member
ensemble
10km
Europe



CAMS users

- Applications
- Policy products



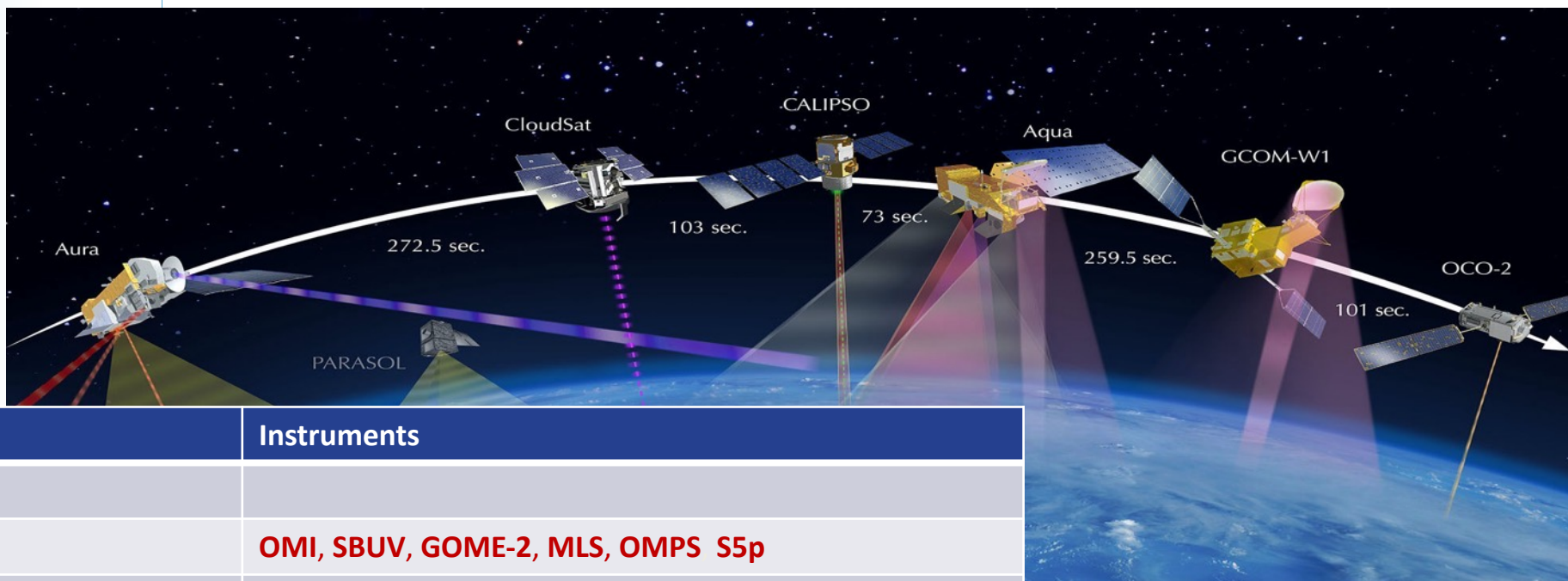
euro
news.





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Earth Observation satellites



Species	Instruments
Global system	
O ₃	OMI, SBUV, GOME-2, MLS, OMPS S5p
CO	IASI, MOPITT, S5p
NO ₂	OMI, GOME-2, S5p
SO ₂	OMI, GOME-2, S5p
Aerosol	MODIS, PMAp, VIIRS, S3
CO ₂	GOSAT, OCO-2
CH ₄	GOSAT, IASI, S5p
GFAS fire emissions	MODIS, SEVIRI*, VIIRS, Sentinel-3, GOES-E/W*, HIMAWARI-8*

CAMS uses Earth Observation data from many satellites for atmospheric composition and weather.

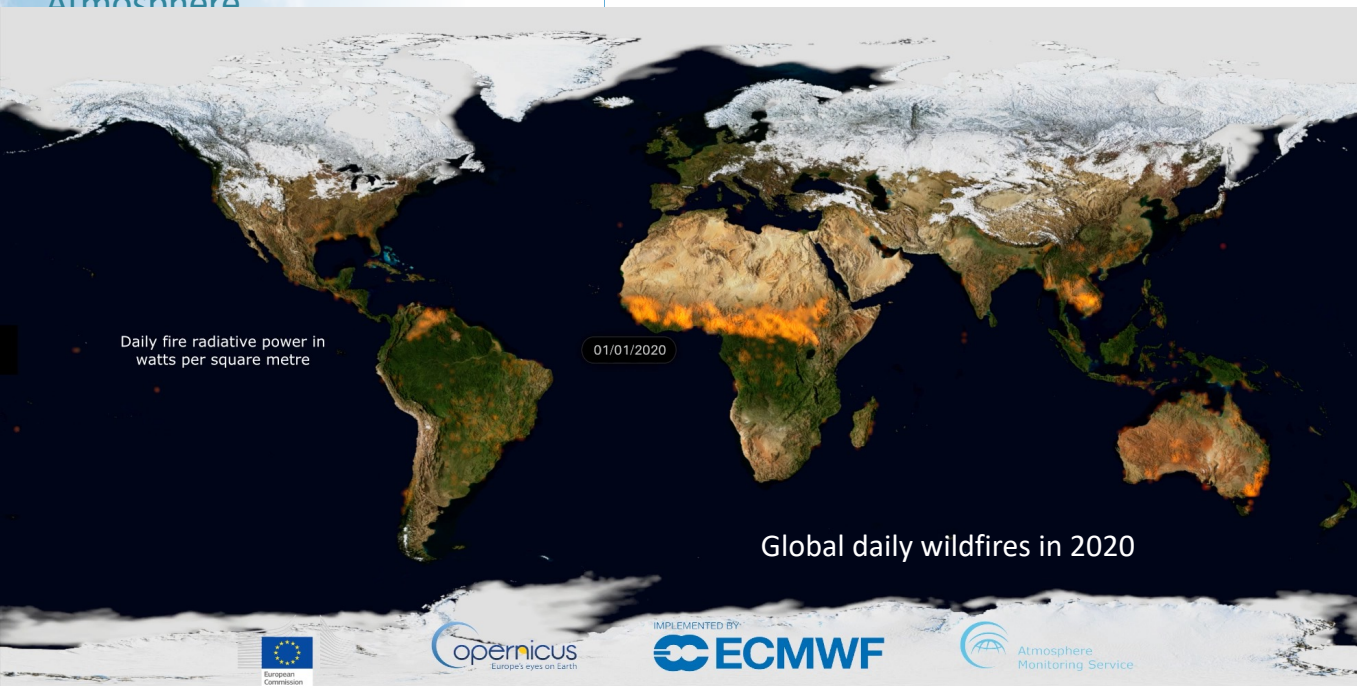
Assimilated **Monitored** Under development

*Geostationary platform



Atmosphere

Estimating Global Wildfire Emissions



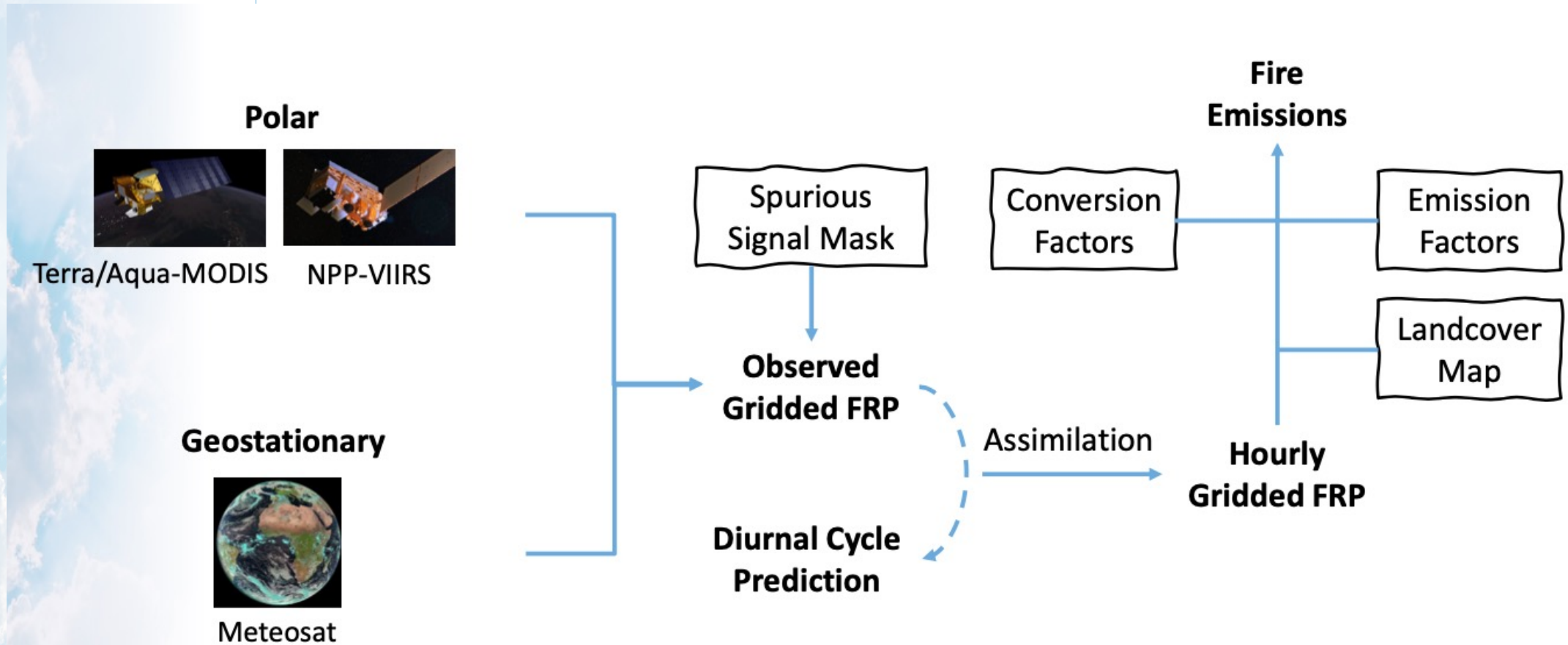
- Satellite observations of fire locations and estimated emissions available from a number of “inventories” (e.g., GFED, FINN, FLAMBE, FEER, GBBEPx, QFED).
- Based generally on similar observations but can differ in the technique used:
 - Burnt area vs. fire radiative power.

- Global Fire Assimilation System (**GFAS**); see <https://ads.atmosphere.copernicus.eu/cdsapp#!/data set/cams-global-fire-emissions-gfas?tab=overview>
- Uses satellite observations of Fire Radiative Power (FRP)
 - Currently Aqua and Terra MODIS FRP observations
 - FRP from VIIRS, Sentinel-3, and geostationary satellites are being tested for future implementation
- Global Coverage at ~10km Resolution
 - *Daily Output: 1-day behind NRT*
 - Hourly Output (+24-h means): 7-hours behind NRT
- Emissions of aerosols and gases are estimated using factors dependent on vegetation type.
- Injection heights calculated with Plume Rise Model and IS4FIRES



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Estimating wildfire emissions



c/o Mark de Jong/Martin Wooster (KCL)
5th CAMS General Assembly



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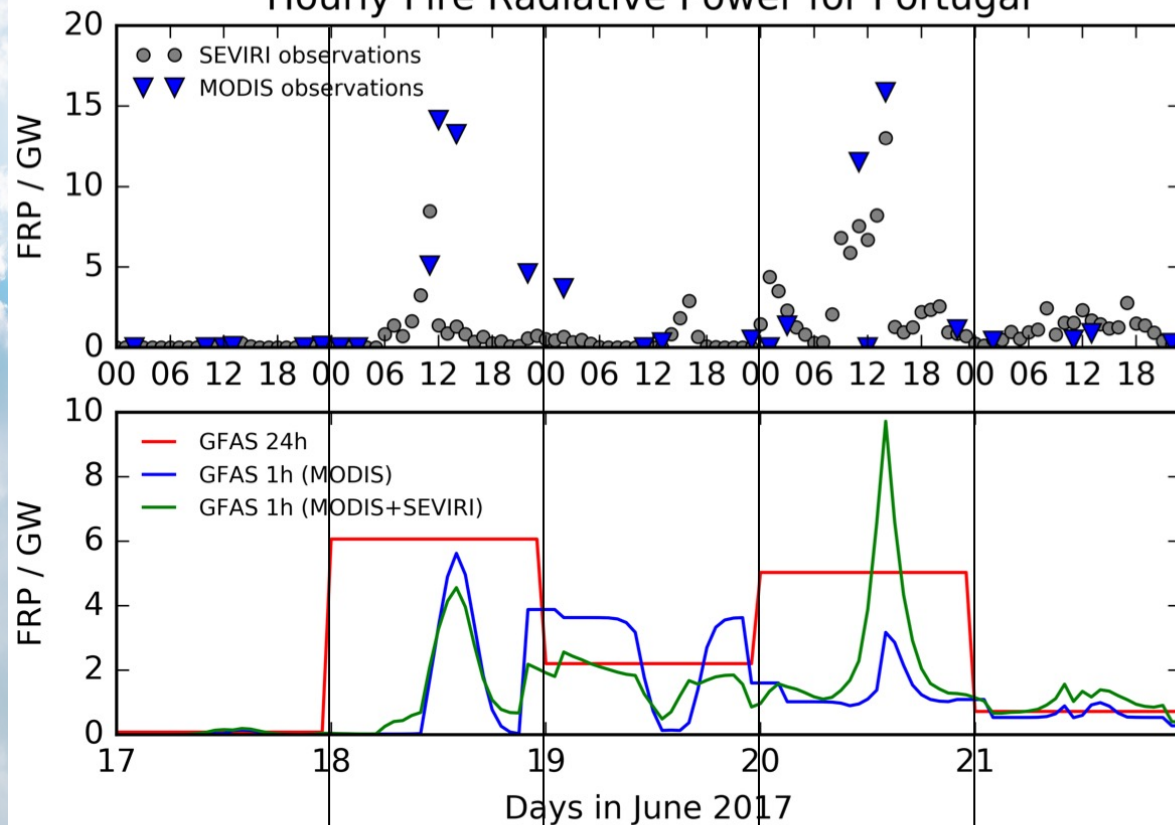


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GFAS hourly fire emissions

Portugal fires 17-22 June 2017: diurnal cycle (including LEO+GEO obs) improves temporal profile of fire emissions

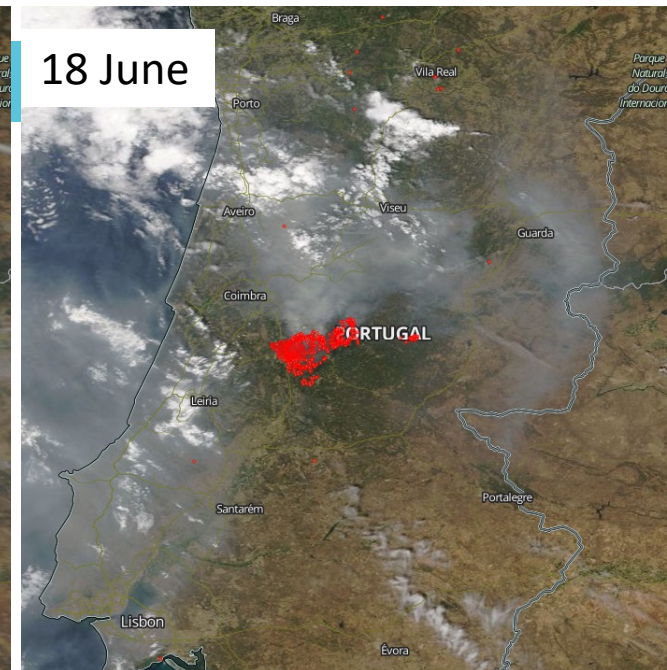
Hourly Fire Radiative Power for Portugal



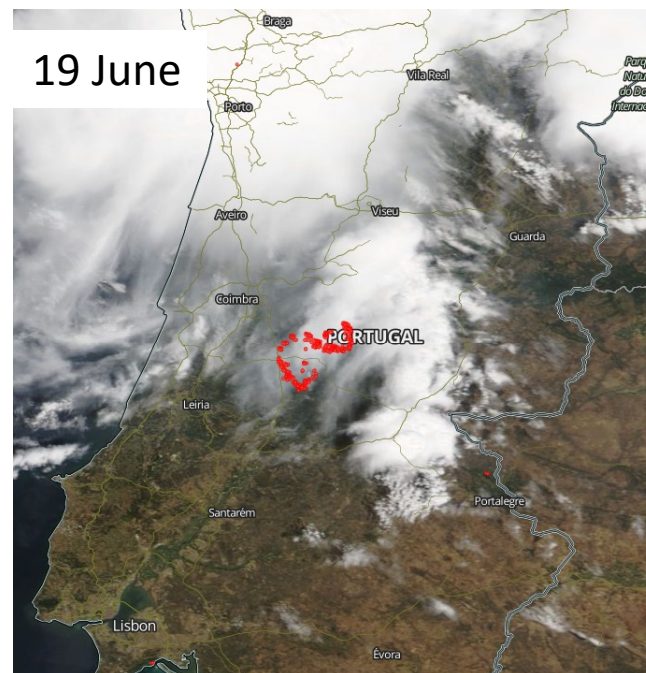
17 June



18 June



19 June



20 June



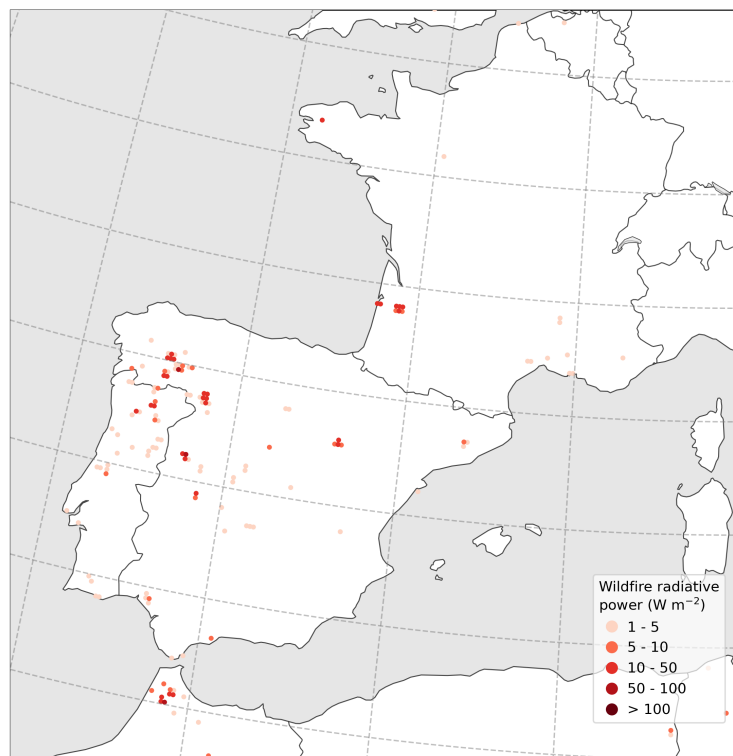
- Fire start reported in afternoon but no observations
- Portugal always at the edge of night-time MODIS swaths
- Fires raging
- First detected at 11 UTC
- Fires burning through the night
- Clouds limit daytime observations
- Fires flare up again
- Distinguishing fires
- extinct at 22/23-06



SW Europe wildfires summer 2022: emissions

GFASv1.2 Total Fire Radiative Power: 2022-07-01 - 2022-07-31

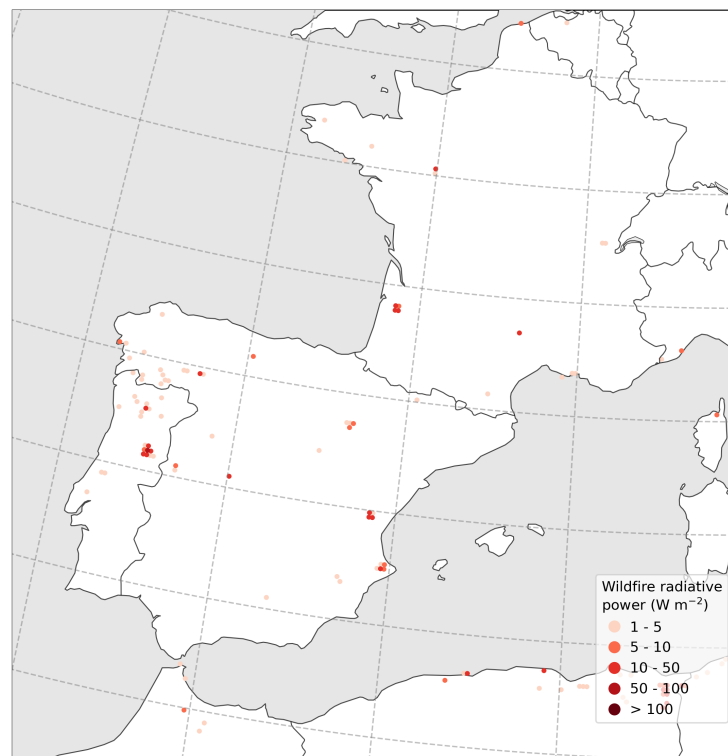
GFASv1.2 Total Fire Radiative Power: August 2022



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EUROPE'S EYES ON EARTH

IMPLEMENTED BY
ECMWF
EUROPEAN CENTRE FOR
MEDIUM-TERM WEATHER
FORECASTS



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EUROPE'S EYES ON EARTH

IMPLEMENTED BY
ECMWF
EUROPEAN CENTRE FOR
MEDIUM-TERM WEATHER
FORECASTS

- Numerous large-scale wildfires across SW Europe in July and August 2022.
 - Also several significant fires across central parts of Europe (e.g., Germany, Czechia, Slovenia, Greece) but focus here on SW Europe.
- CAMS GFAS data provide near-real-time (within 7 hours) information on intensity and estimated emissions of wildfires (and open burning).
 - 20-year dataset provides context.



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Europe's eyes on Earth

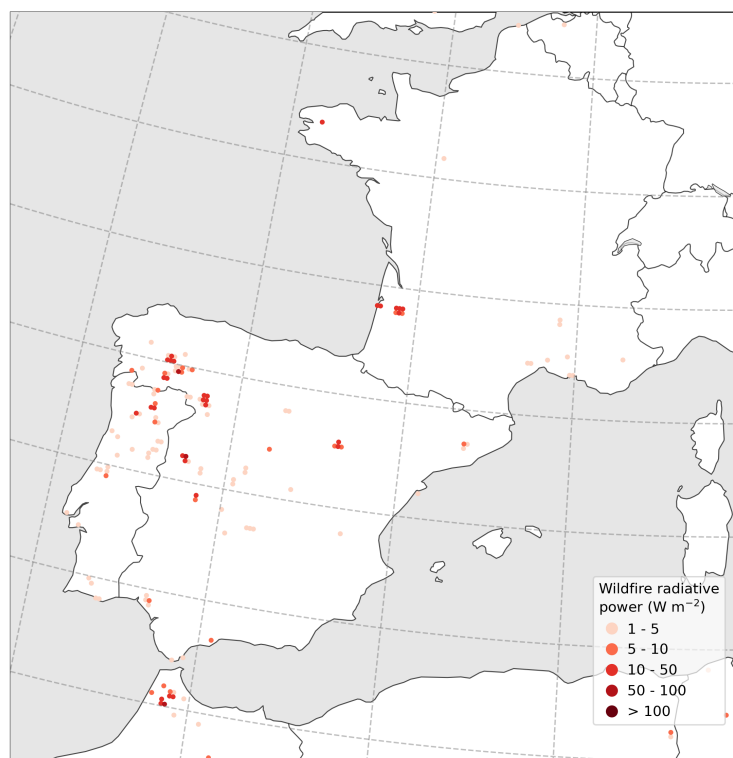
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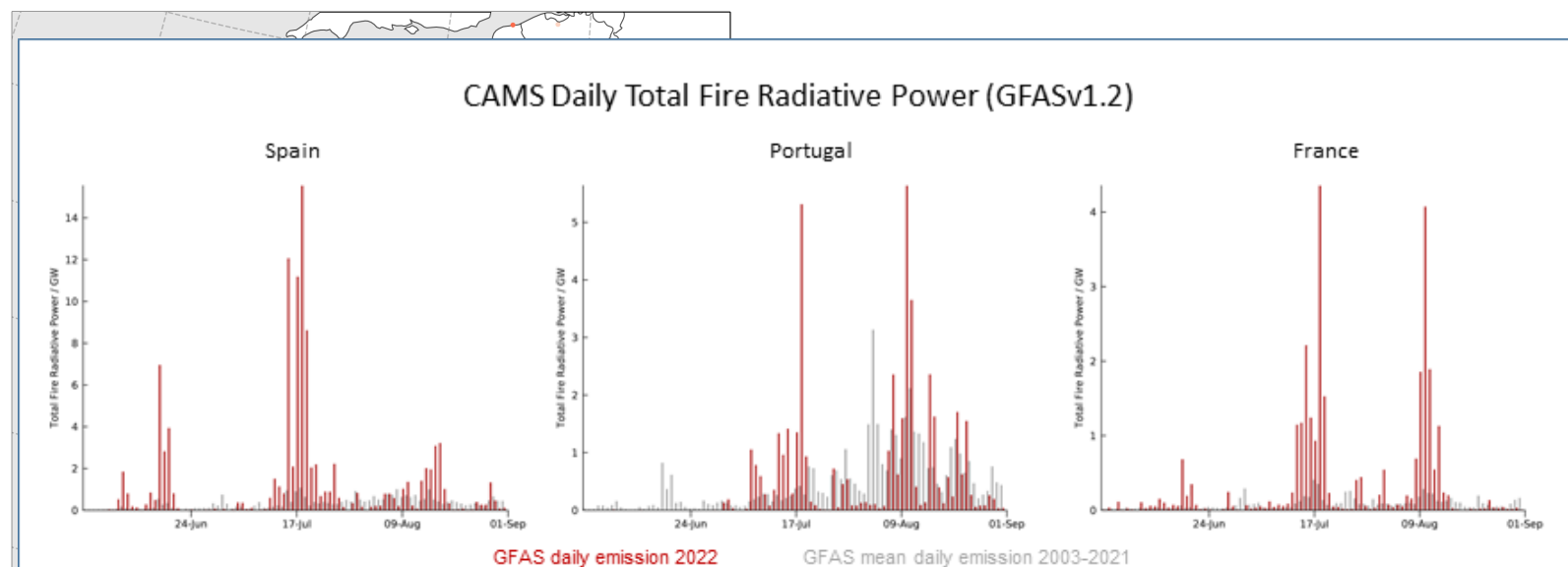
SW Europe wildfires summer 2022: emissions

GFASv1.2 Total Fire Radiative Power: 2022-07-01 - 2022-07-31

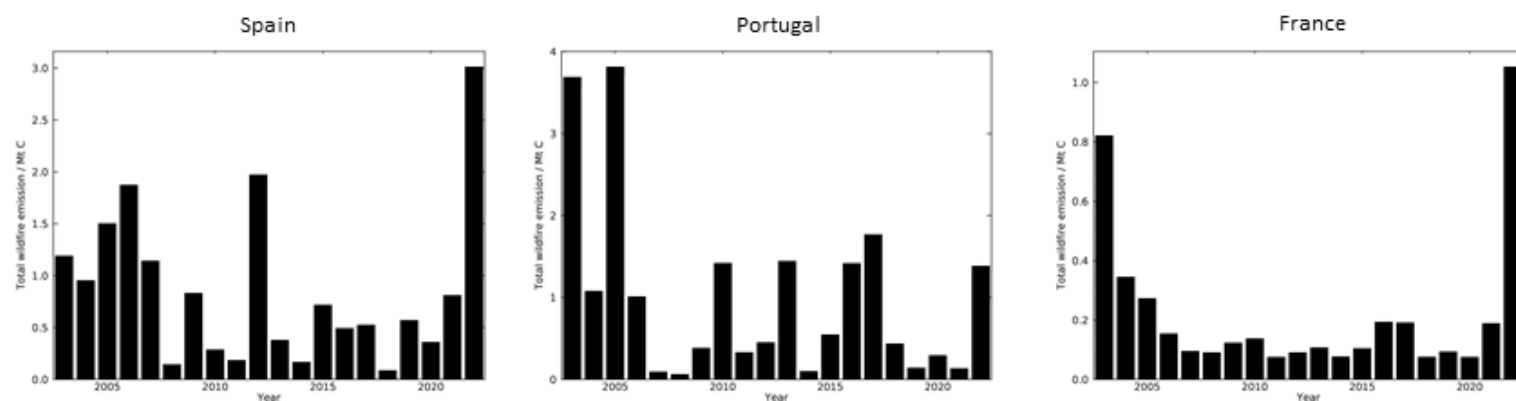
GFASv1.2 Total Fire Radiative Power: August 2022



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June-August Total Estimated Wildfire Carbon Emissions



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Atmosphere Monitoring Service

- Numerous large-scale wildfires across SW Europe
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- CAMS GFAS data provide near-real-time (within 7 intensity and estimated emissions of wildfires (ar
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SW Europe wildfires summer 2022: smoke monitoring

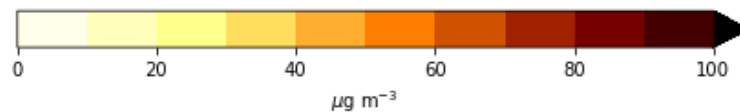
Regional air quality forecasts show high resolution local smoke impacts and spread

<https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-europe-air-quality-forecasts?tab=overview>

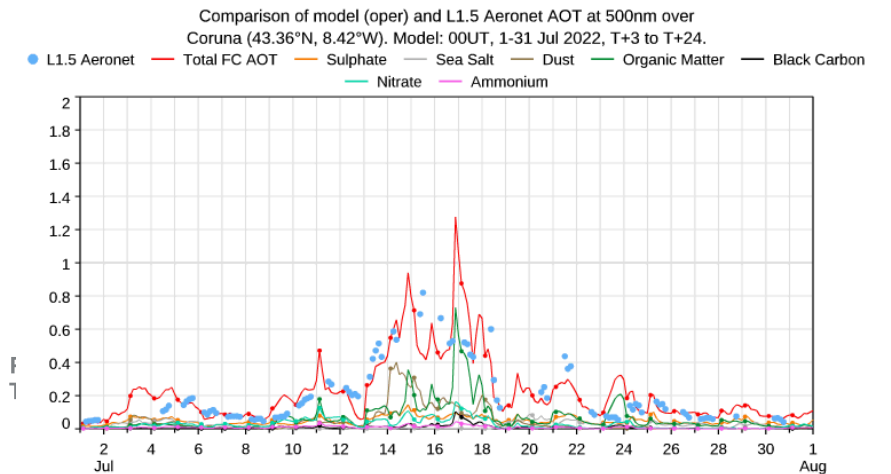
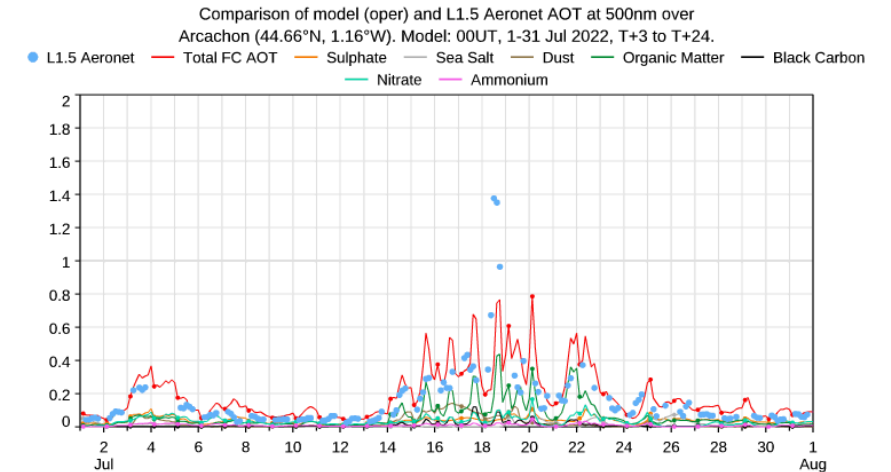
Global atmospheric composition forecasts

<https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-atmospheric-composition-forecasts?tab=overview>

CAMS Regional Ensemble Forecast Daily Max Surface PM2.5 Concentration: 20220710T00 valid for 2022-07-10



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Linking Copernicus Services: From fire monitoring to fire forecasts



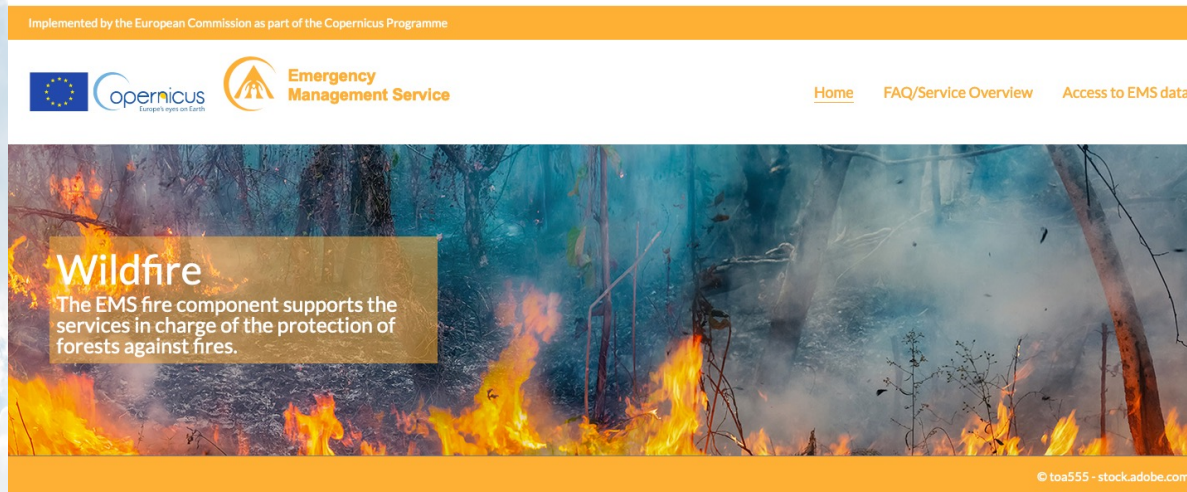
CAMS



Copernicus Emergency Management Service

Global Fire
monitoring

Global fire evolution forecasting (d+5)
Global fire danger forecasting (d+10)



Information for emergency response and disaster risk management.

<https://emergency.copernicus.eu/>

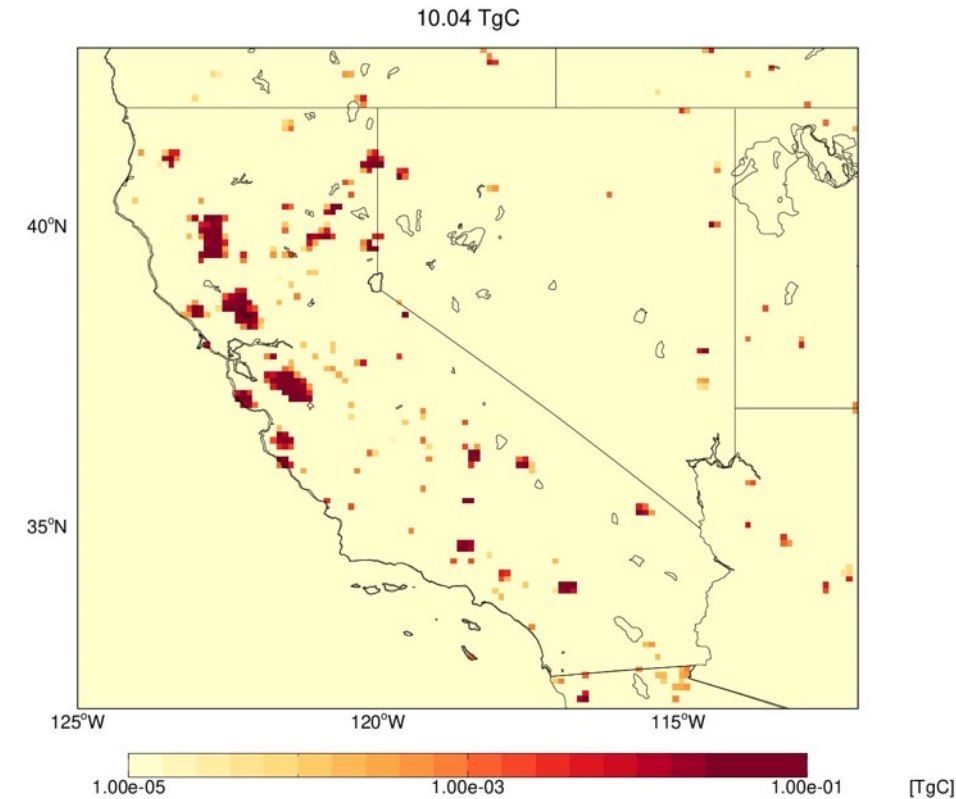
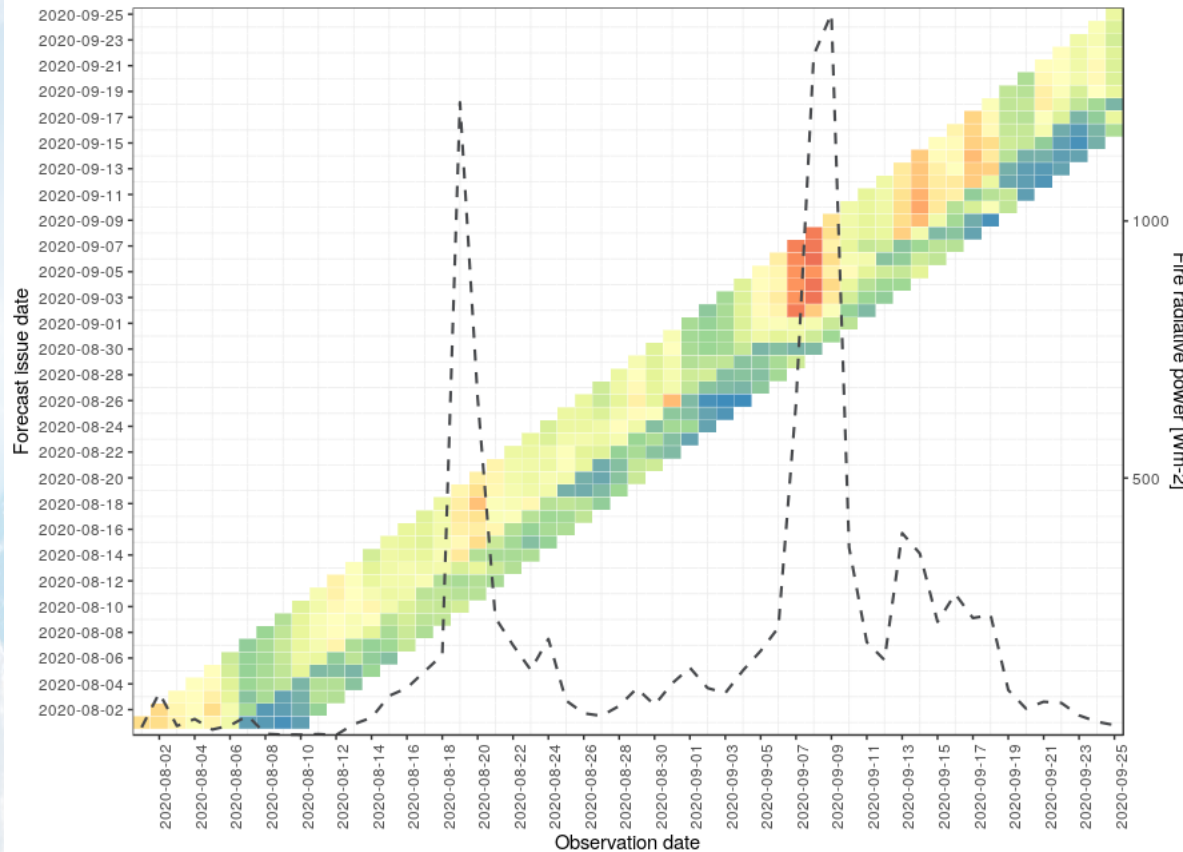
The European Forest Fire Service (EFFIS) is implemented by the EU Joint Research Centre

Flood and fire danger forecasts are provided by ECMWF.





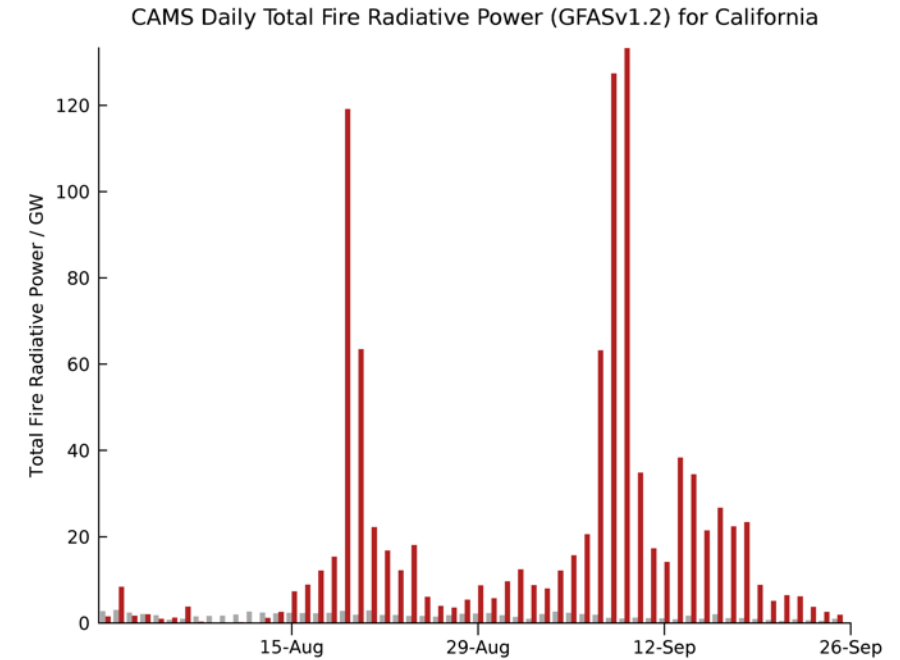
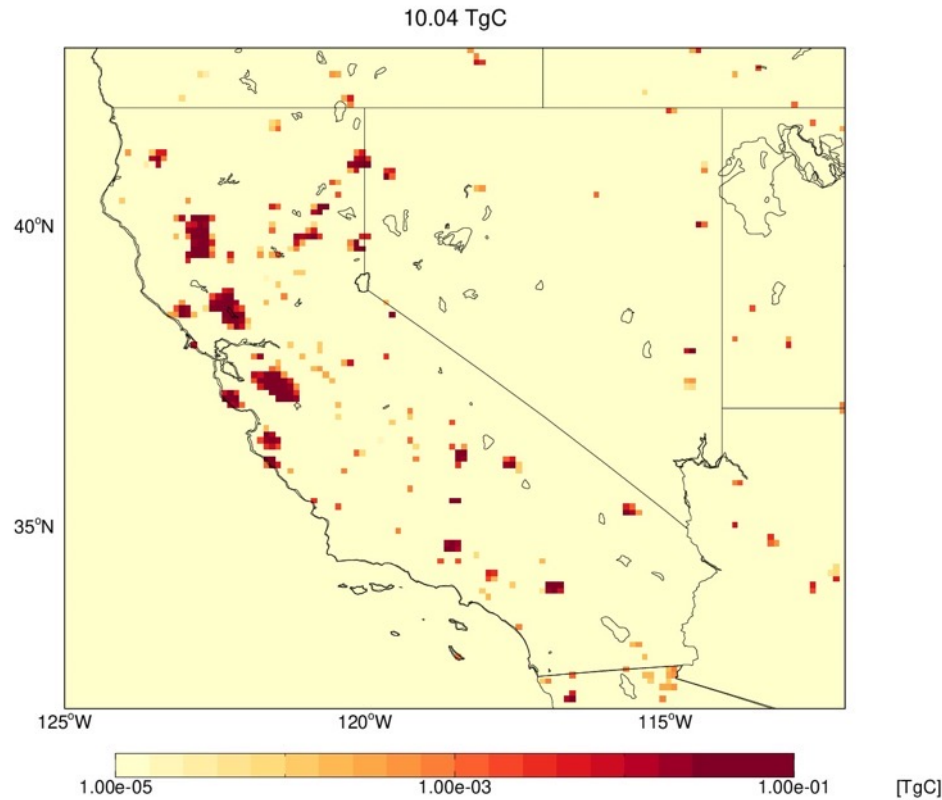
California fires in August-September 2020



- As in previous cases, highest % of pixels exceeding very high fire danger rating in California forecast 6-8 days ahead of fire activity between 18-22 August and 5-10 September.
- Strong correspondence with highest % and observed active fire emissions.
- Air quality impacts of smoke persisted across California (and the western states) for many days and eventual long-range transport to the North Atlantic and as far as Europe.



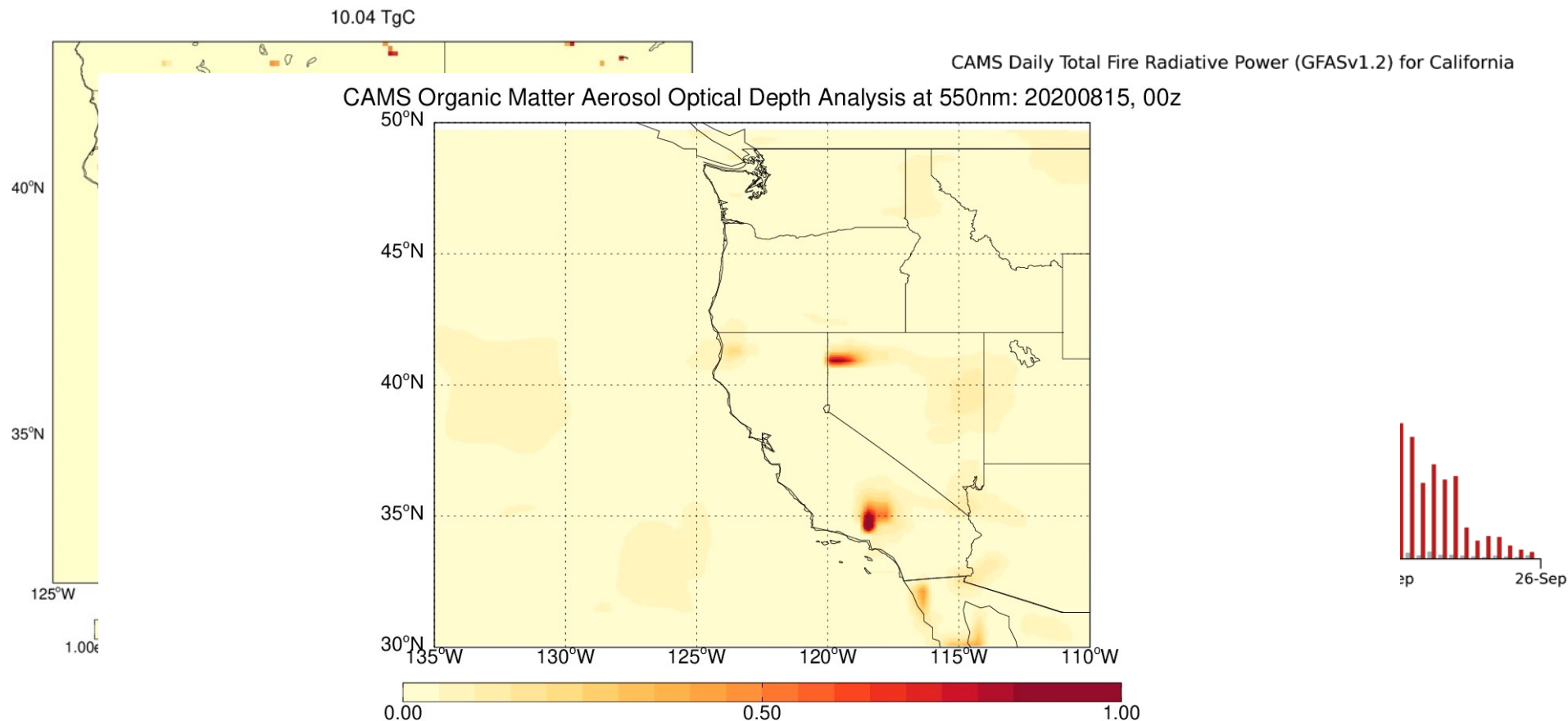
CAMS in action: California fires in August-September 2020



- Widespread wildfires across California and western states through August and September 2020.
- GFAS data used to monitor state-level active fires location and intensity.
- CAMS global analyses and forecasts of aerosol optical depth and total column carbon monoxide used to monitor local and long-range smoke transport.



CAMS in action: California fires in August-September 2020



- Widespread
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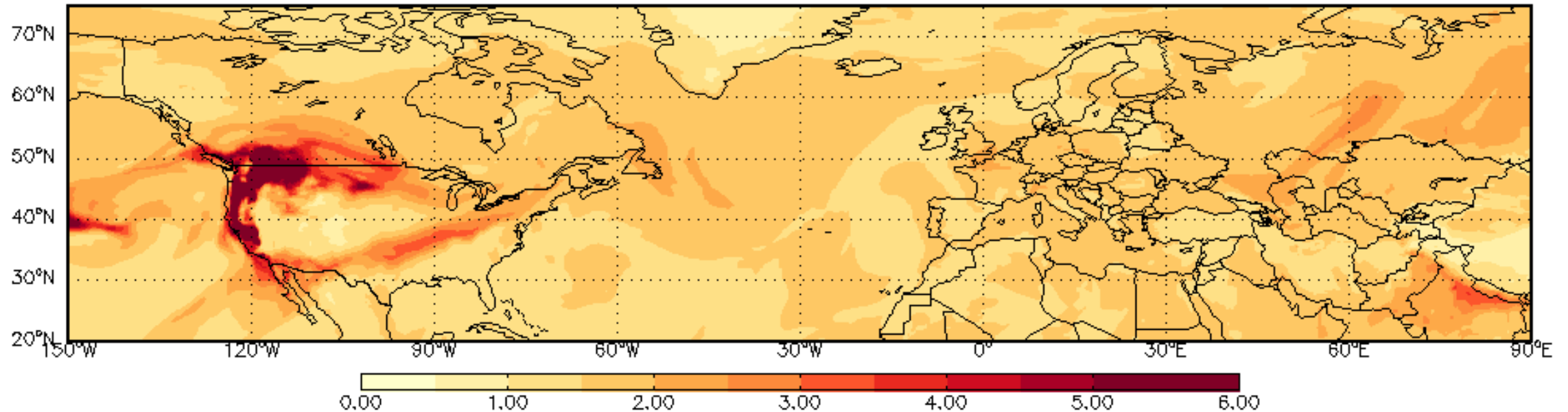
CAMS in action: California fires in August-September 2020

10.04 TgC



CAMS Daily Total Fire Radiative Power (GFASv1.2) for California

CAMS Total Column Carbon Monoxide [10^{18} mol/cm²]: 20200914, 00z



CAMS global analyses and forecasts of aerosol optical depth and total column carbon monoxide used to monitor local and long-range smoke transport.



Future directions for fire monitoring in Copernicus and ECMWF

- CAMS (and CEMS) provides operational, near-real-time, independent information on global fire weather and emissions. All data are free and open access.
 - Future developments will bring elements of these services closer together to provide end-to-end information on the role of fires in atmospheric composition.
 - Several case studies which show consistent agreement between forecasts and observed activity in different regions around the world.
- A diurnal cycle of fire emissions has been developed in GFAS to provide hourly emissions estimates based on FRP observations from Low Earth Orbit (MODIS, VIIRS, Sentinel-3) and Geostationary Orbit (SEVIRI, GOES-R/-S, Himawari-8).
- Modelling of the fire emissions, following the fire danger forecasts will improve atmospheric composition forecasts with more realistic changes to environmental changes over the duration of the forecast (currently fixed in CAMS air quality forecasts).